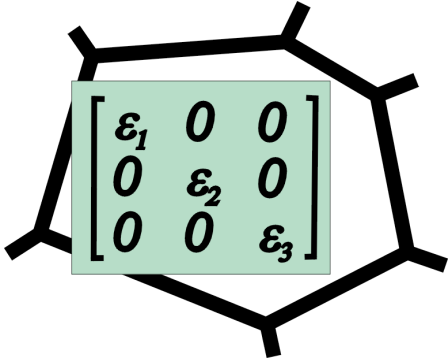
UNIWERSYTET ŚLĄSKI
W KATOWICACH



Changing SAM geometry and generation of phyllotactic patterns

Dorota Kwiatkowska

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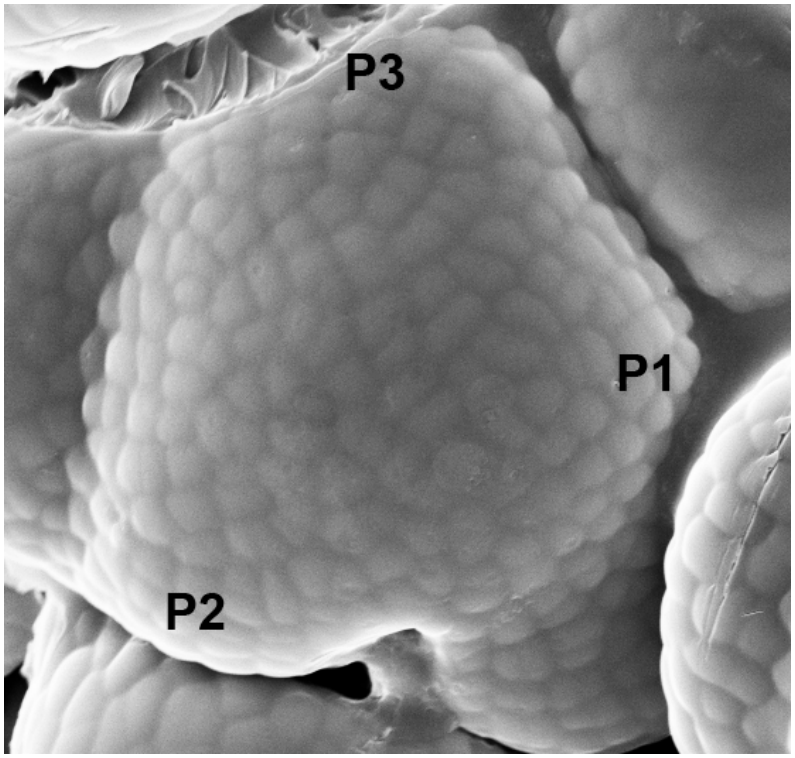
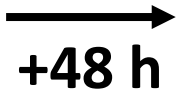
Institute of Biology, Biotechnology and Environment Protection
University of Silesia in Katowice, Poland

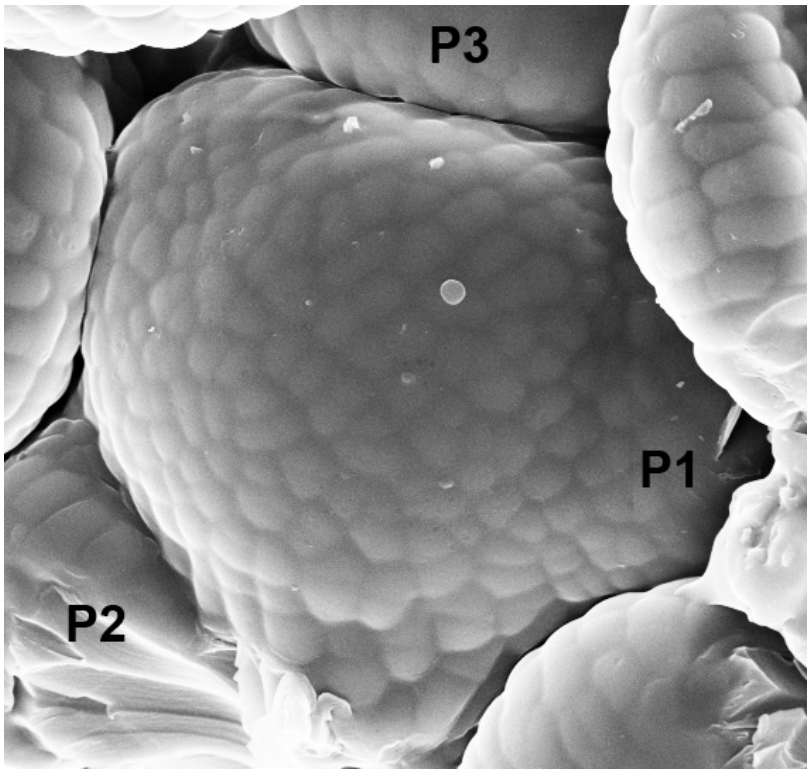
- Fundamental SAM functions: **self-maintenance** and **primordium initiation**
- From **axi-symmetric** to **a-symmetric** apical domes
- **SAM/primordium boundaries**: partitioning of SAM surface
- Relative primordium size: the problem of **primordia packing**
- Phyllotaxy at various scales: from **apex** to **elongated stem**

Fundamental SAM functions:

general SAM shape and size are **maintained** despite continuous **primordia initiation** at the periphery







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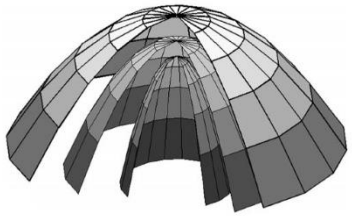
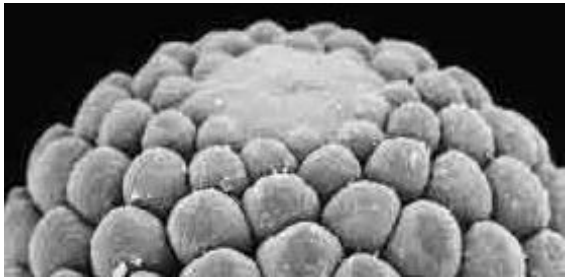


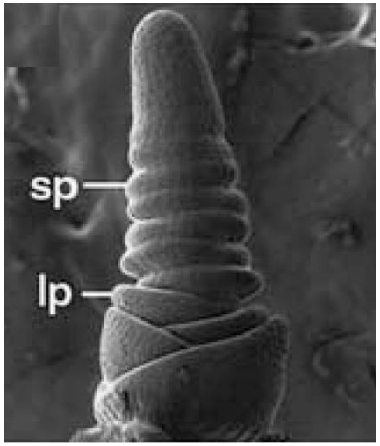
From **axi-**symmetric to **a-**symmetric apical domes:

- **relatively small SAMs**
- **fewer symmetry planes**
- **SAM shape related to phyllotaxis**



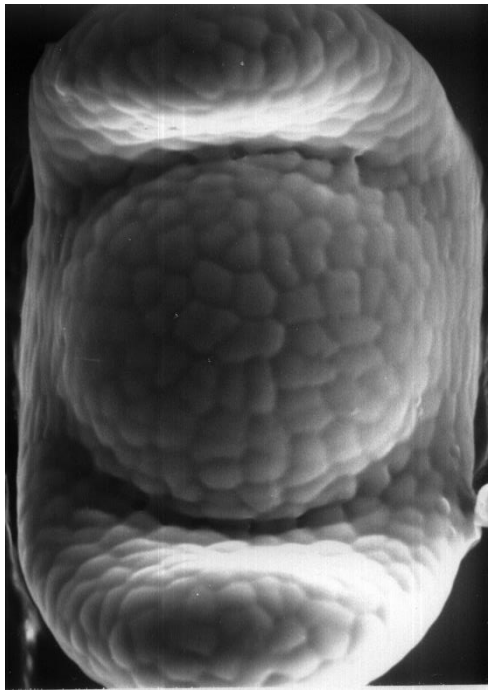
(almost) **axi-symmetric** spruce (*Picea*)

R.Rutishauser

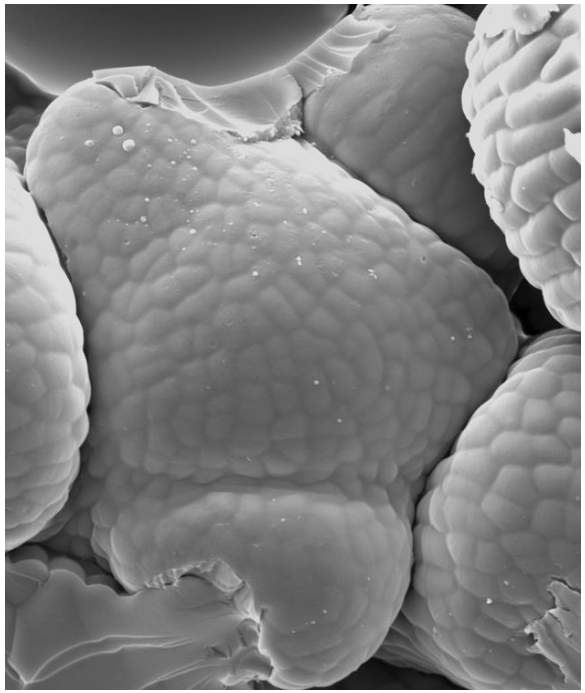


(almost) **axi-symmetric** barley (*Hordeum*)

Babb & Muehlbauer 2003



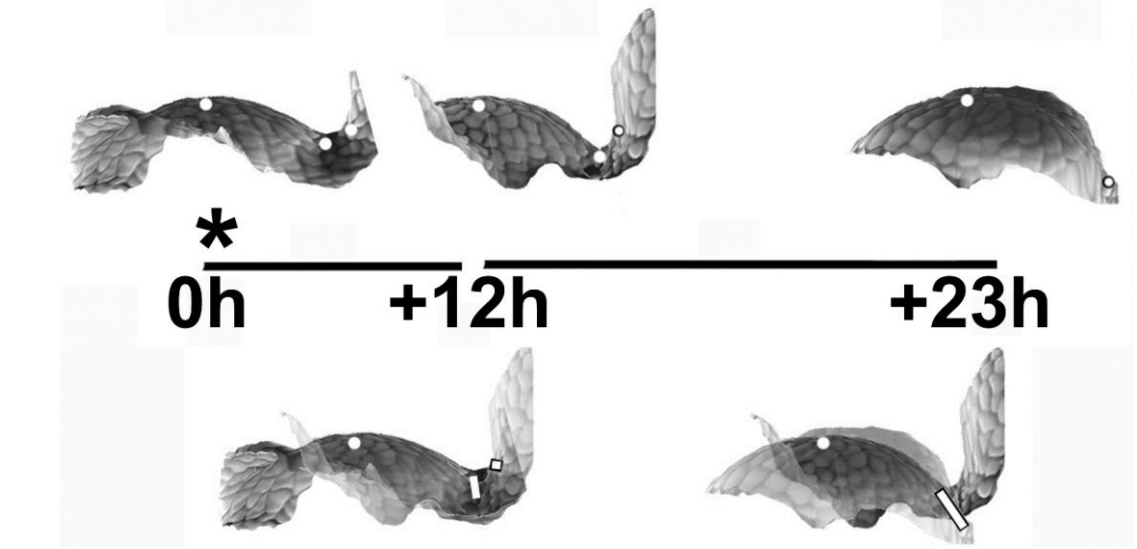
Anagallis with **two symmetry planes** and decussate phyllotaxis



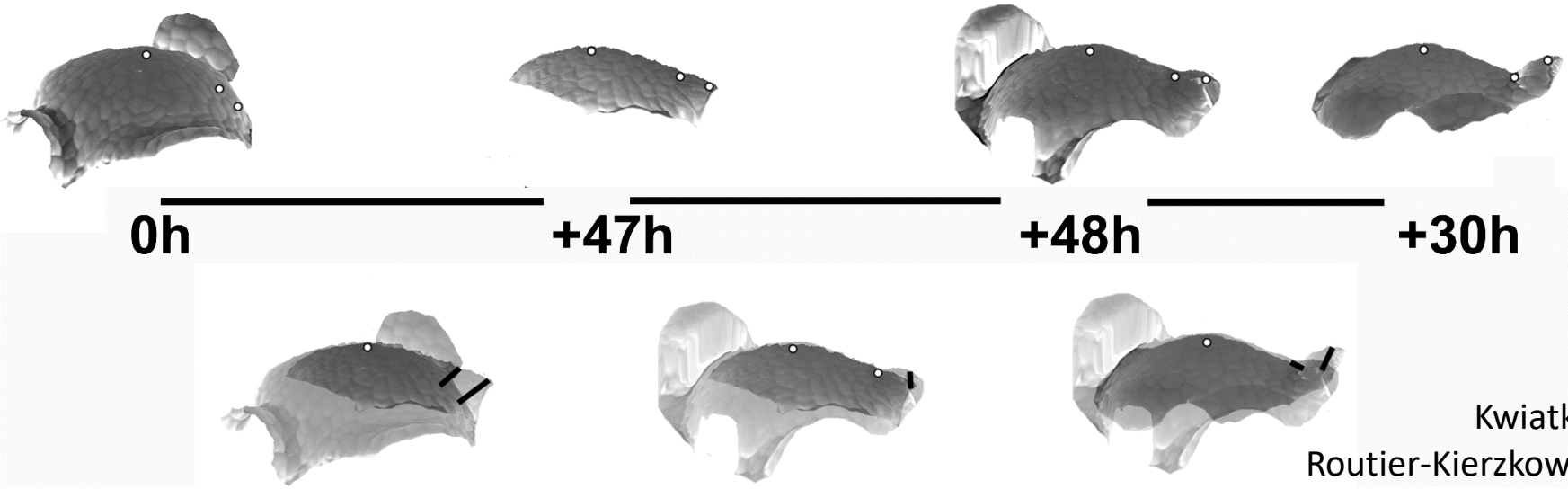
a-symmetric *Arabidopsis* with spiral phyllotaxis

From **axi-**symmetric to **a-**symmetric apical domes:

- **relatively small SAMs exhibit spatiotemporal geometry changes**



profiles of *Anagallis* shoot apex in:
vegetative
&
reproductive
developmental phase



Kwiatkowska &
Routier-Kierzkowska 2009

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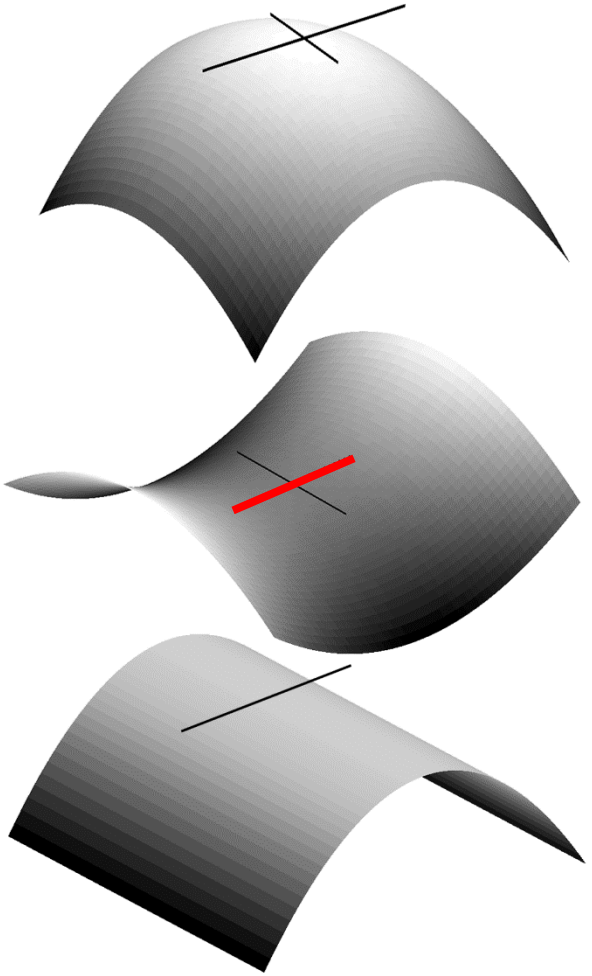
Formation of **SAM/primordium boundaries** leads to partitioning of the SAM surface

unique Gaussian curvature and **curvature directions at boundaries** mark:

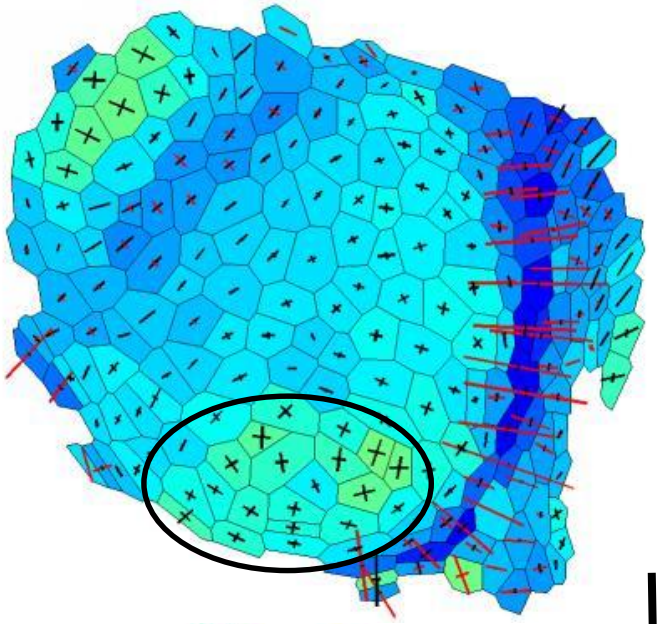
single boundary at vegetative *Anagallis SAM*

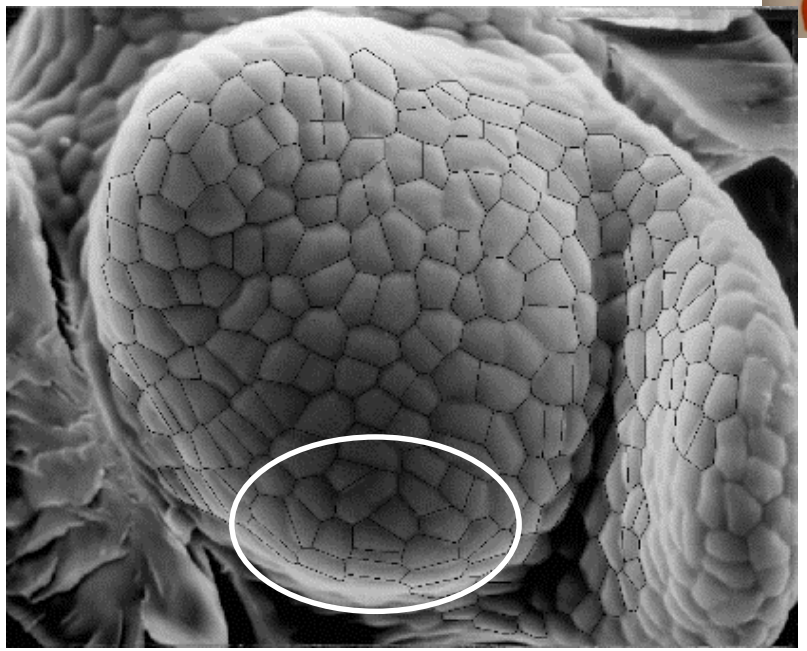
vs.

double boundary at *Arabidopsis* SAM in reproductive phase

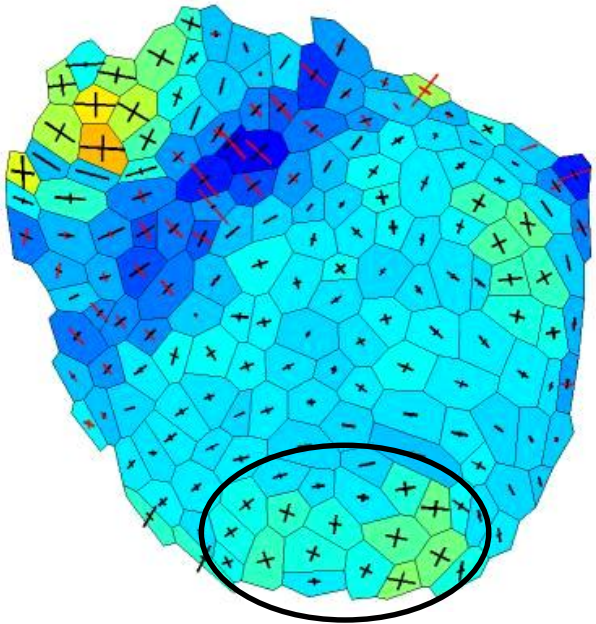


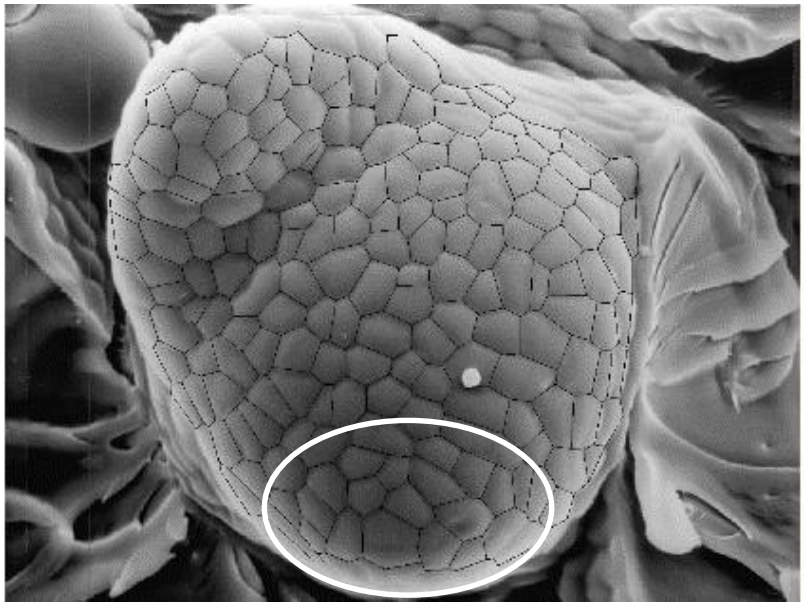
Anagallis SAM in vegetative phase: **increased Gaussian curvature** at the site of leaf primordium initiation



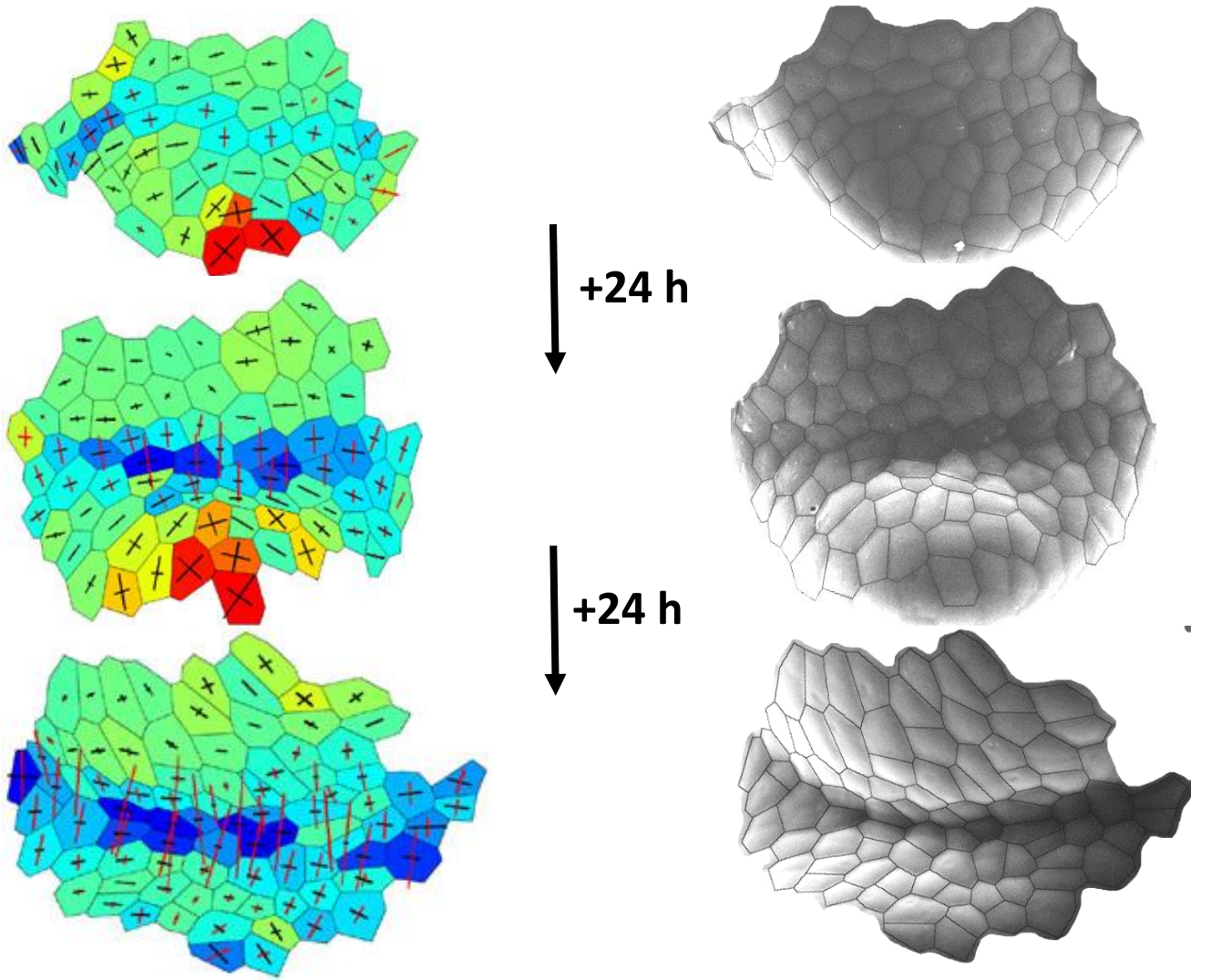


+24 h



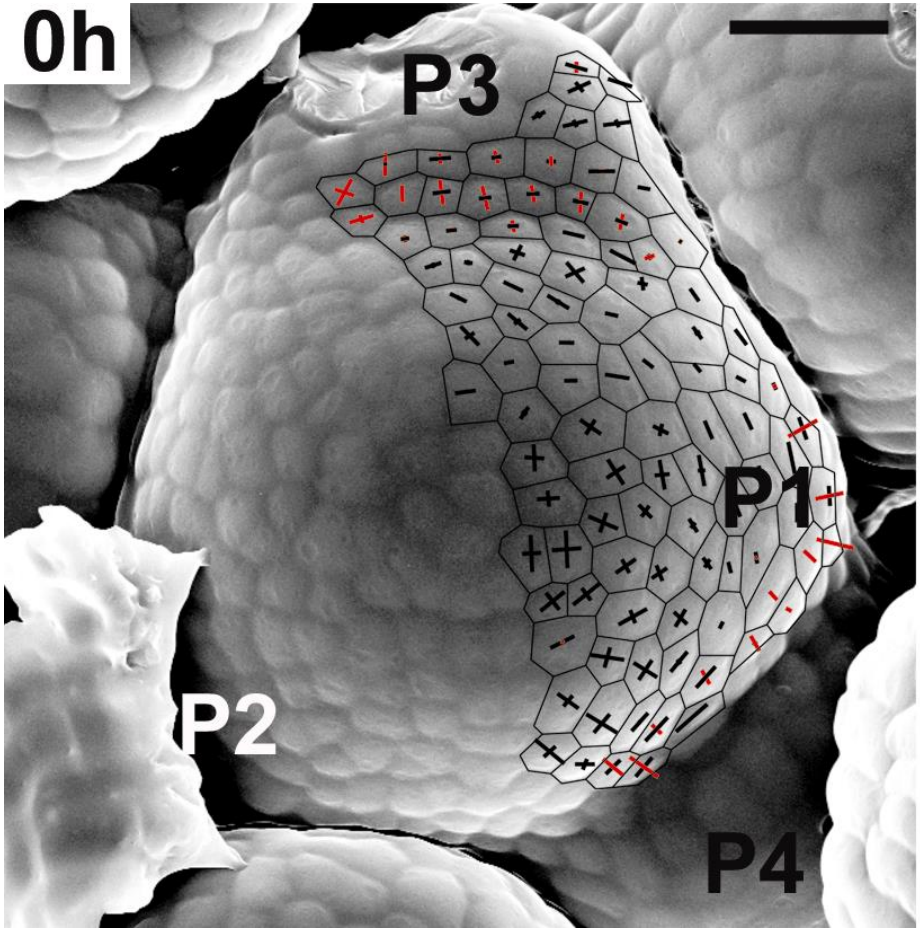


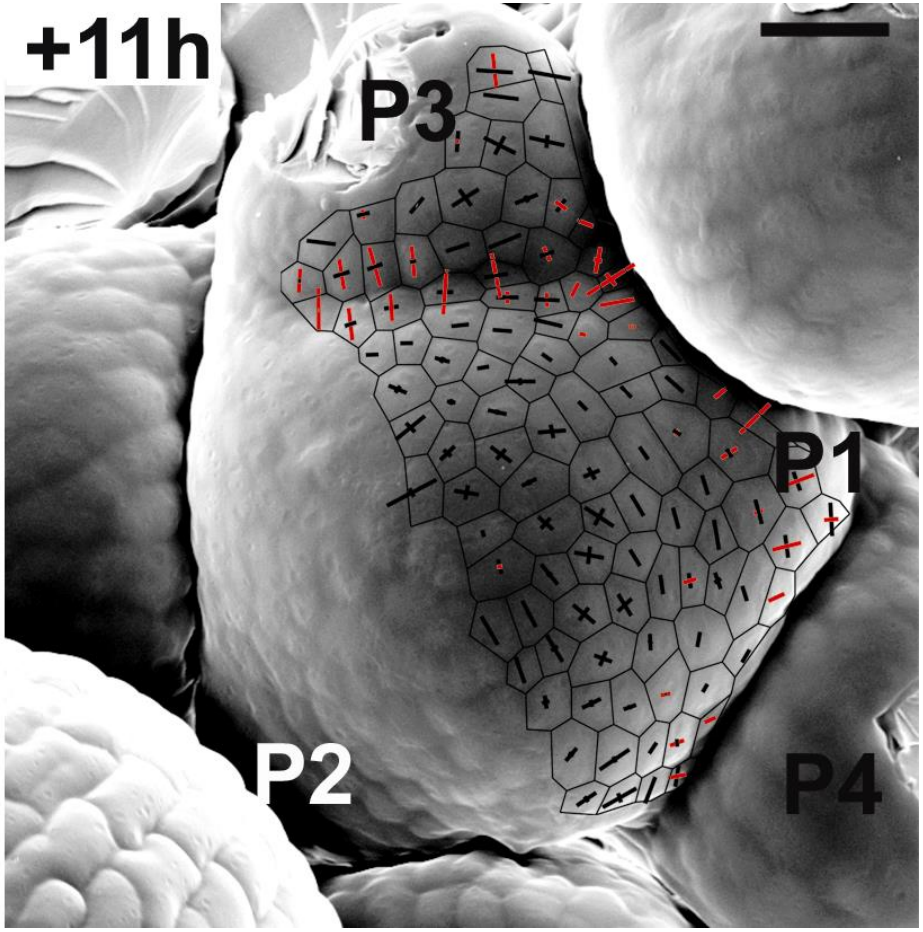
Anagallis SAM in vegetative phase: final surface partitioning marked by **crease formation** (**negative Gaussian curvature**)



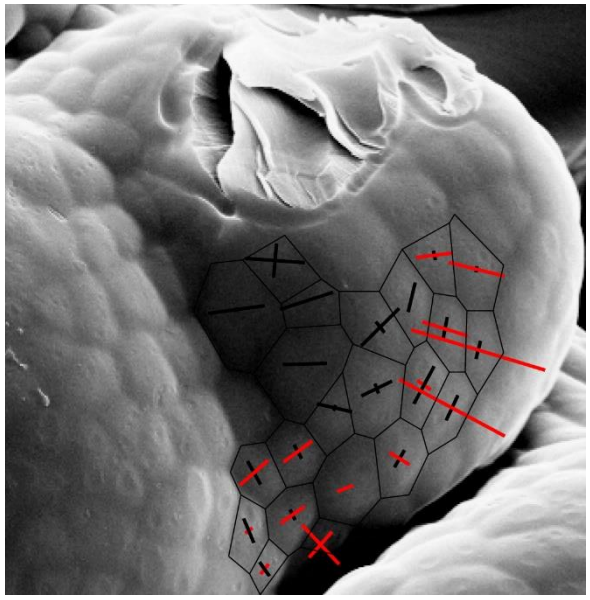
Kwiatkowska & Dumais 2003

Arabidopsis SAM in reproductive phase: **more than one boundary** is formed





Kwiatkowska 2006

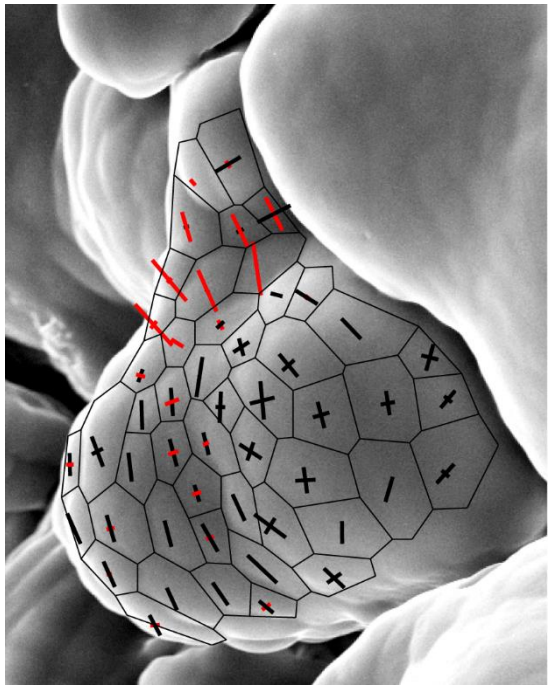


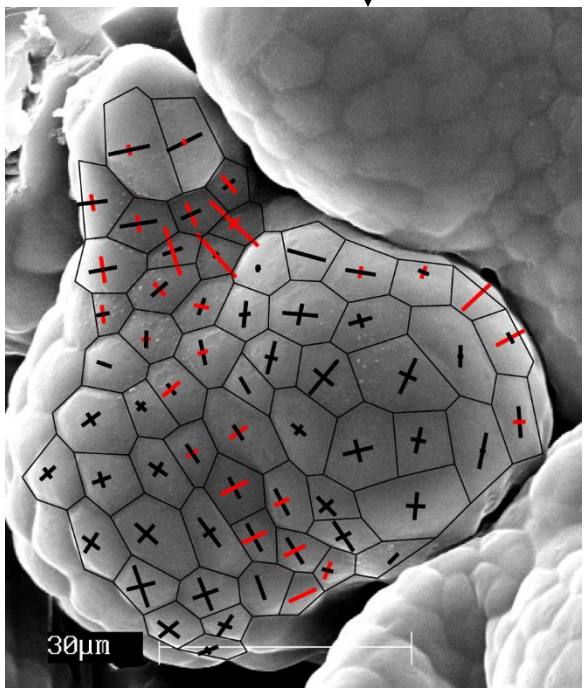
1st crease at SAM/bract boundary disappears in Col-0 but not in bract suppression mutant

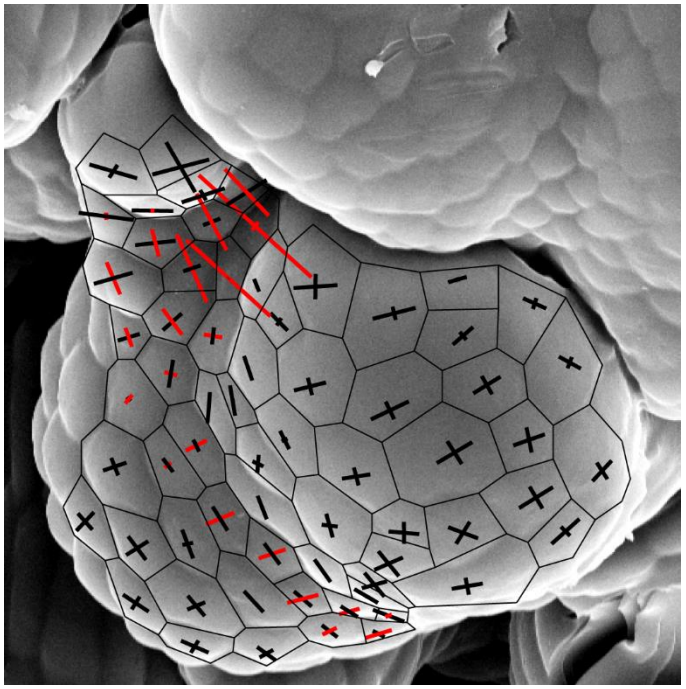
2nd crease at SAM/FM

Col-0

puchi







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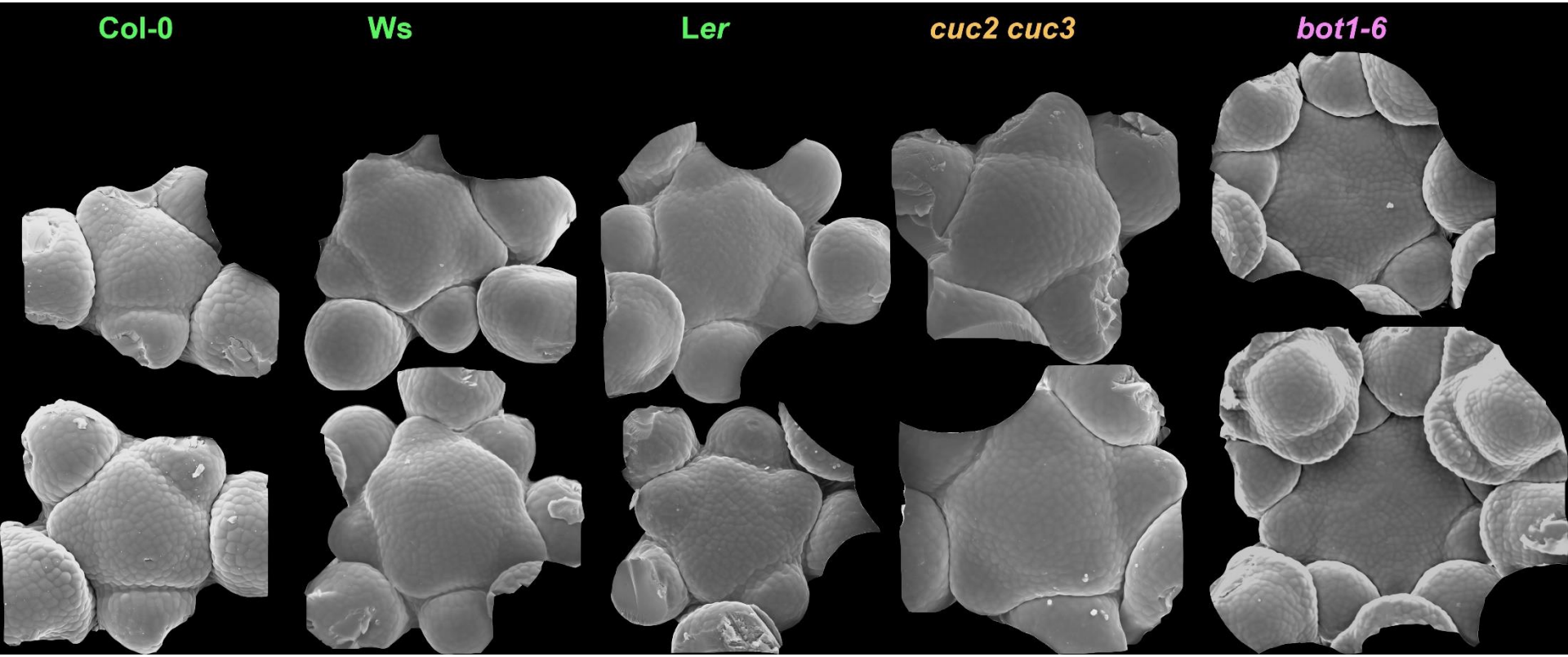
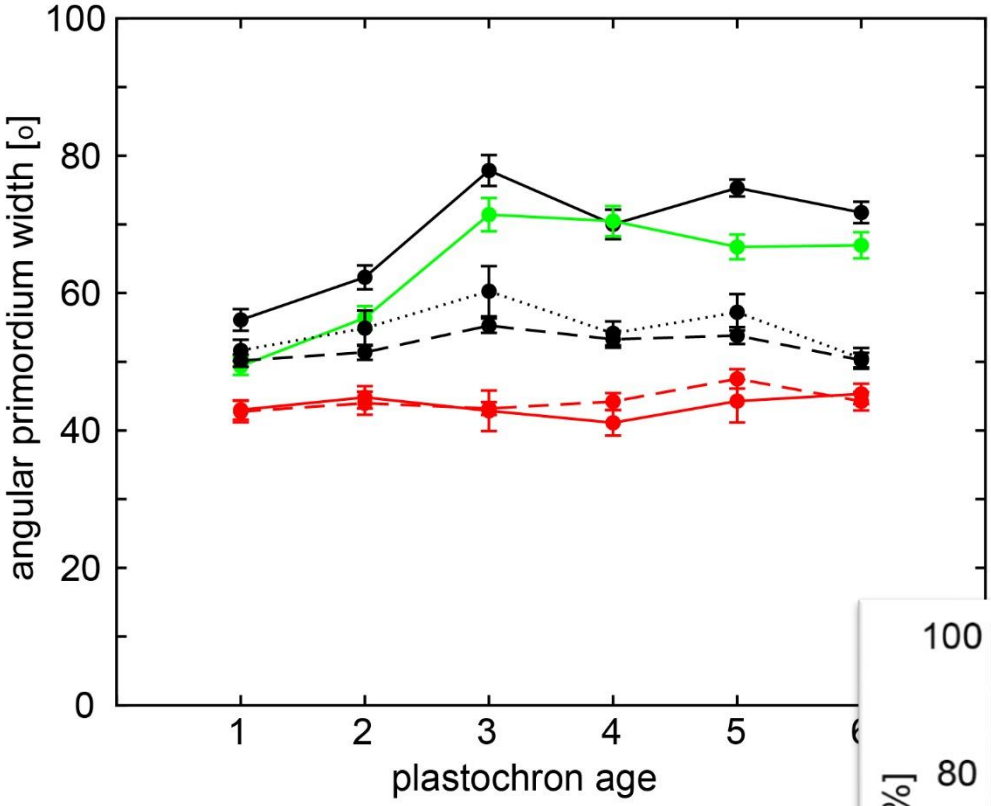
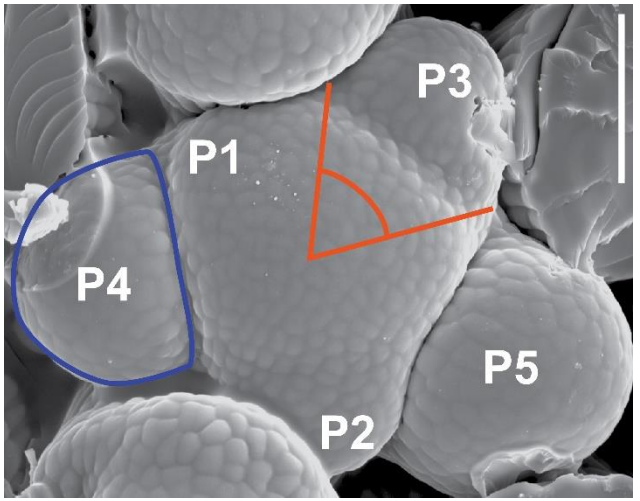
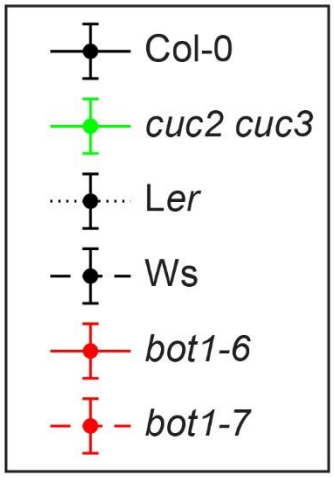
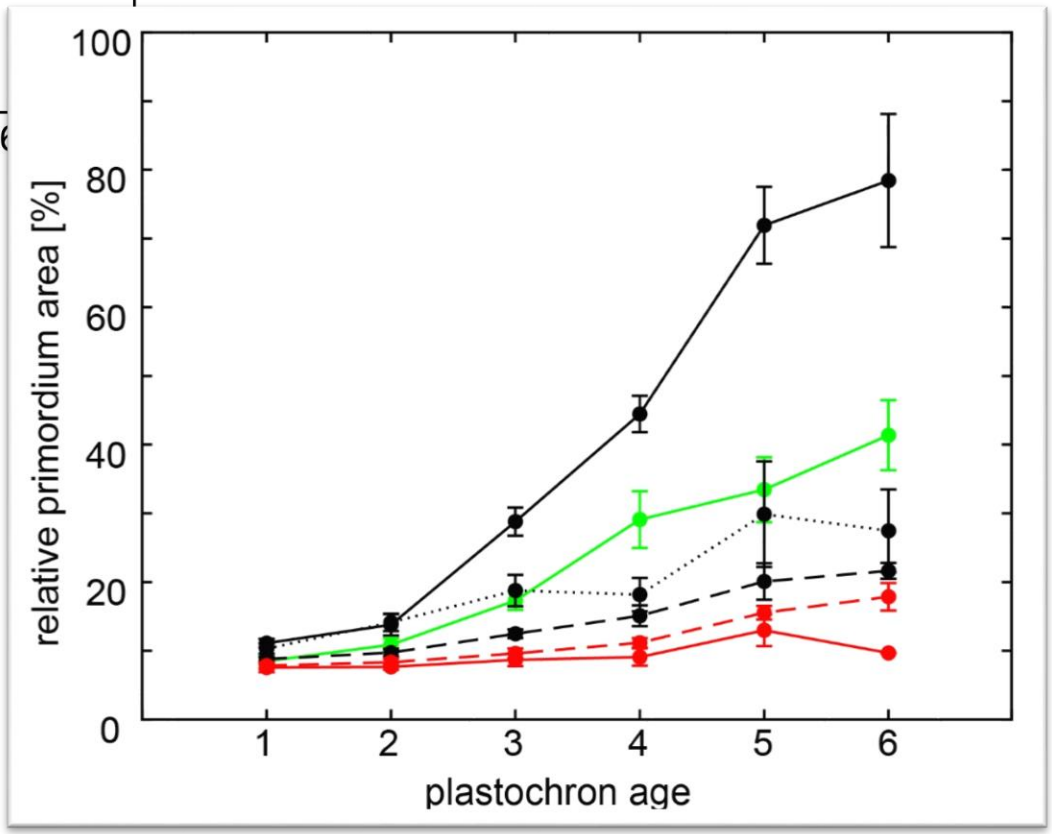
Different relative primordium sizes and different **primordia packing** in *A. thaliana* inflorescence SAM



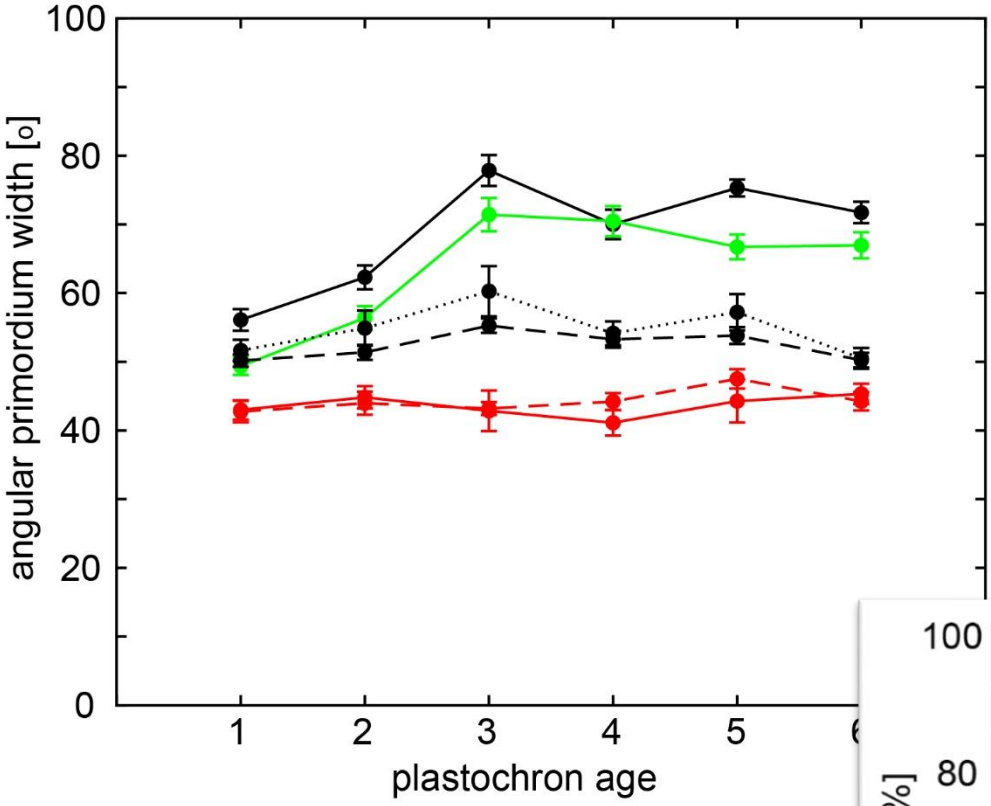

angular primordium width [°]
100
80
60
40
20
0
1
2
3
4
5
plastochron age

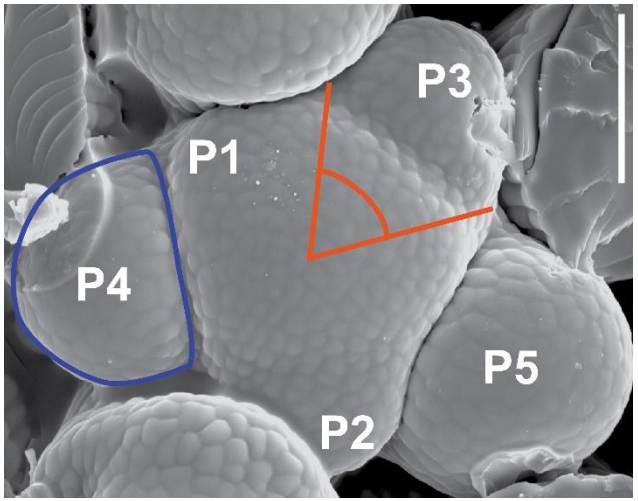

P1
P2
P3
P4
P5

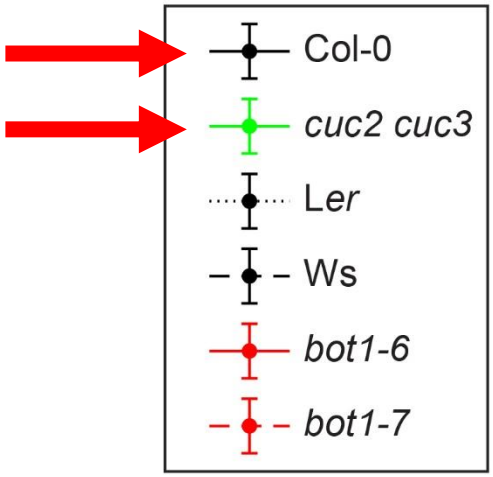

Col-0
cuc2 cuc3
Ler
Ws
bot1-6
bot1-7

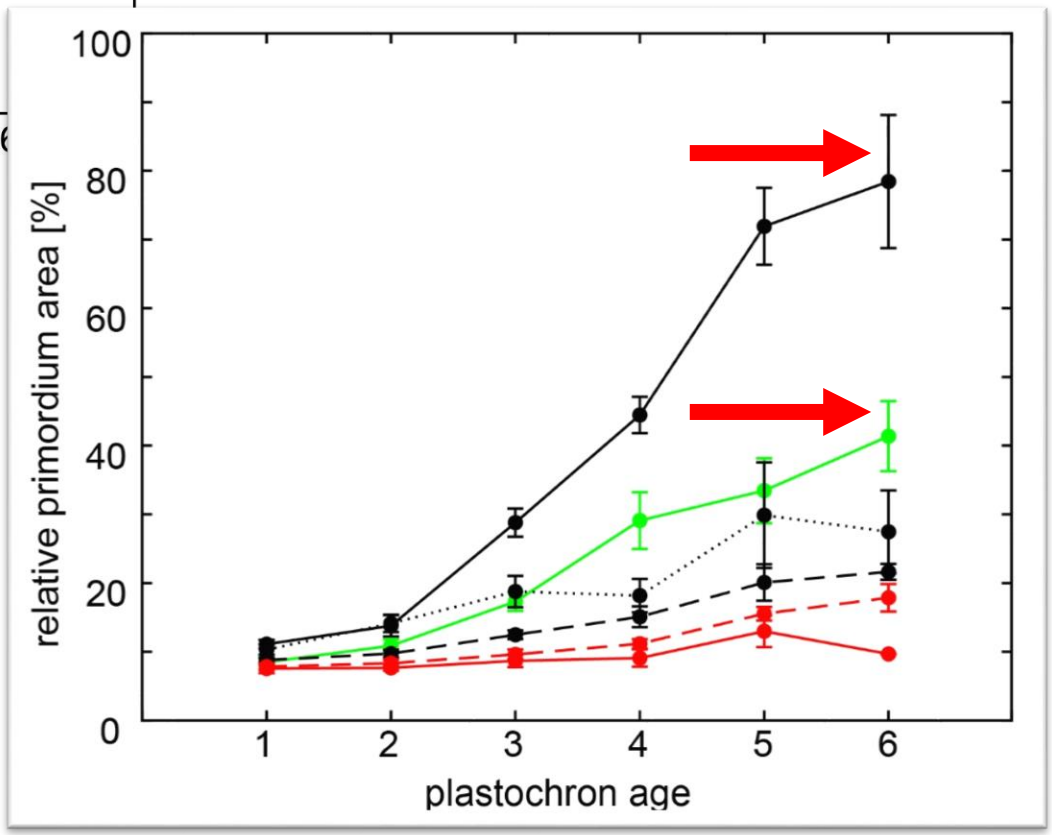

relative primordium area [%]
100
80
60
40
20
0
1
2
3
4
5
6
plastochron age

means +/- SE


angular primordium width [°]
100
80
60
40
20
0
1
2
3
4
5
plastochron age


P1
P2
P3
P4
P5

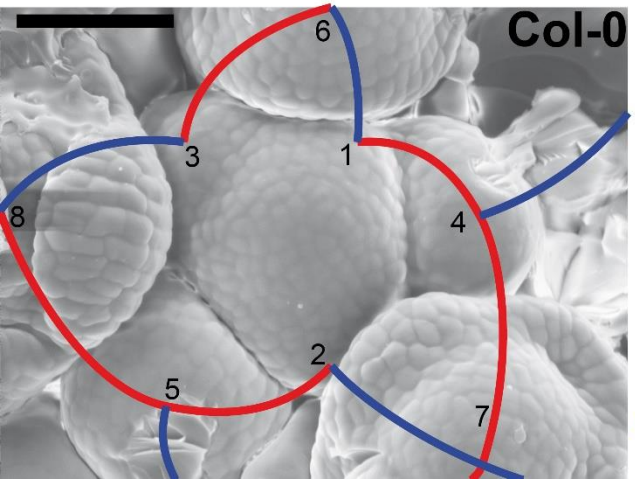

Col-0
cuc2 cuc3
Ler
Ws
bot1-6
bot1-7

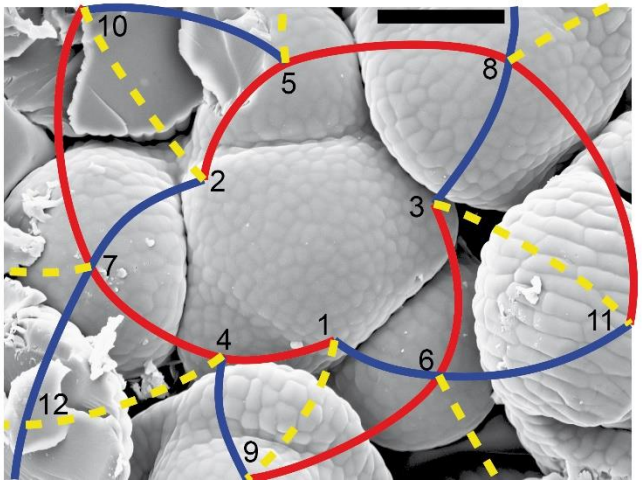

relative primordium area [%]
100
80
60
40
20
0
1
2
3
4
5
6
plastochron age

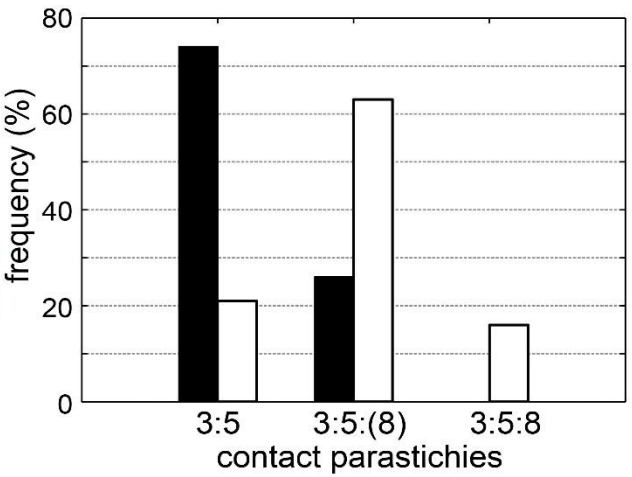
means +/- SE

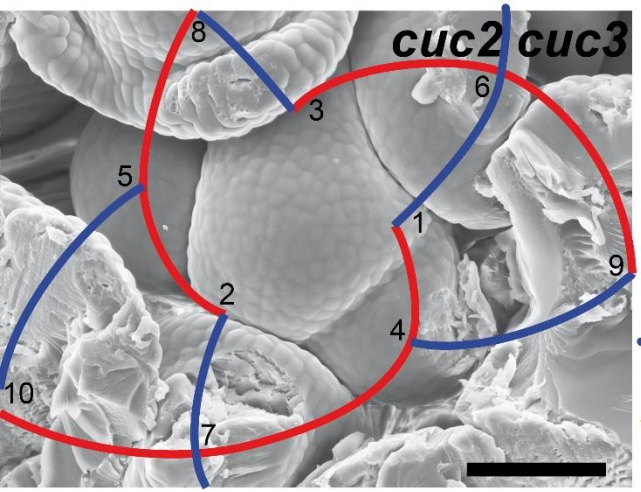
cuc2 cuc3 *vs.* Col-0:

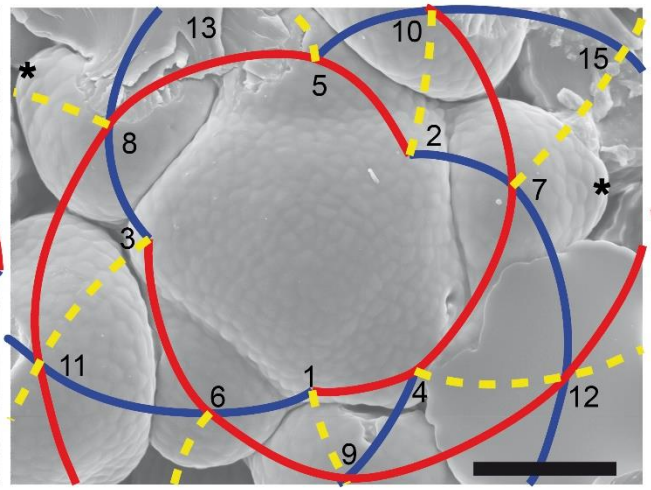
- absolute SAM size increased, but not primordium size
- **smaller relative primordium size** accompanies **denser primordia packing** (higher *Contact Parastichies*) around the SAM

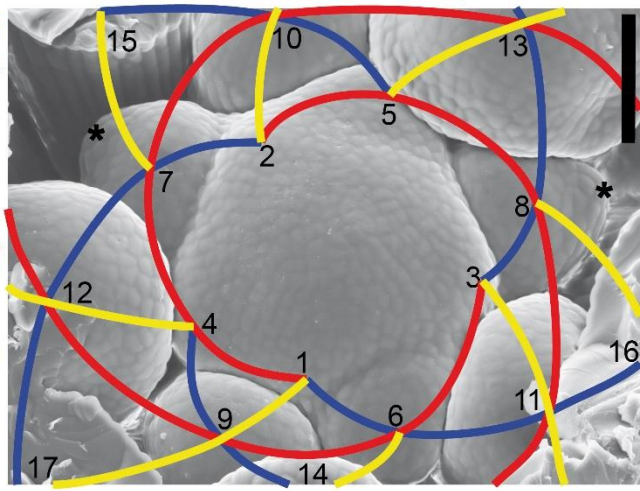












Burian et al. 2015

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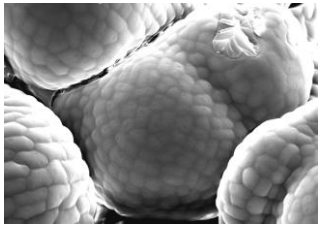
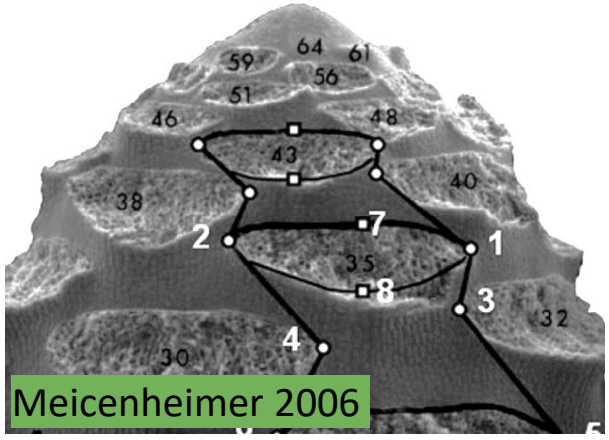
Primordia packing and **phyllotaxy at various scales**: from **apices** to **elongated stems**

Arabidopsis

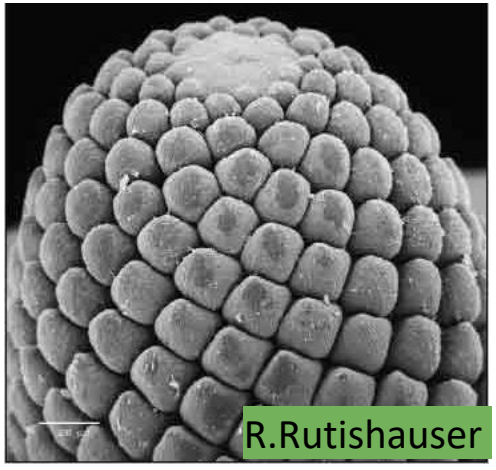


Linum



Meicenheimer 2006

Picea

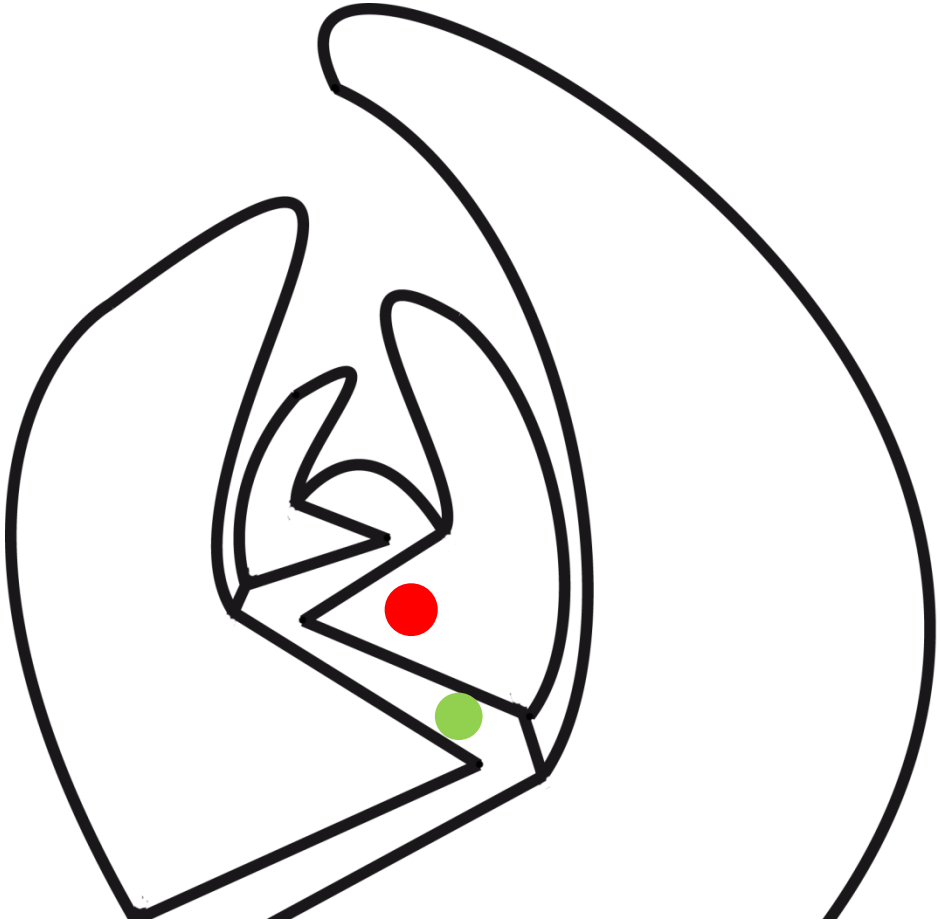


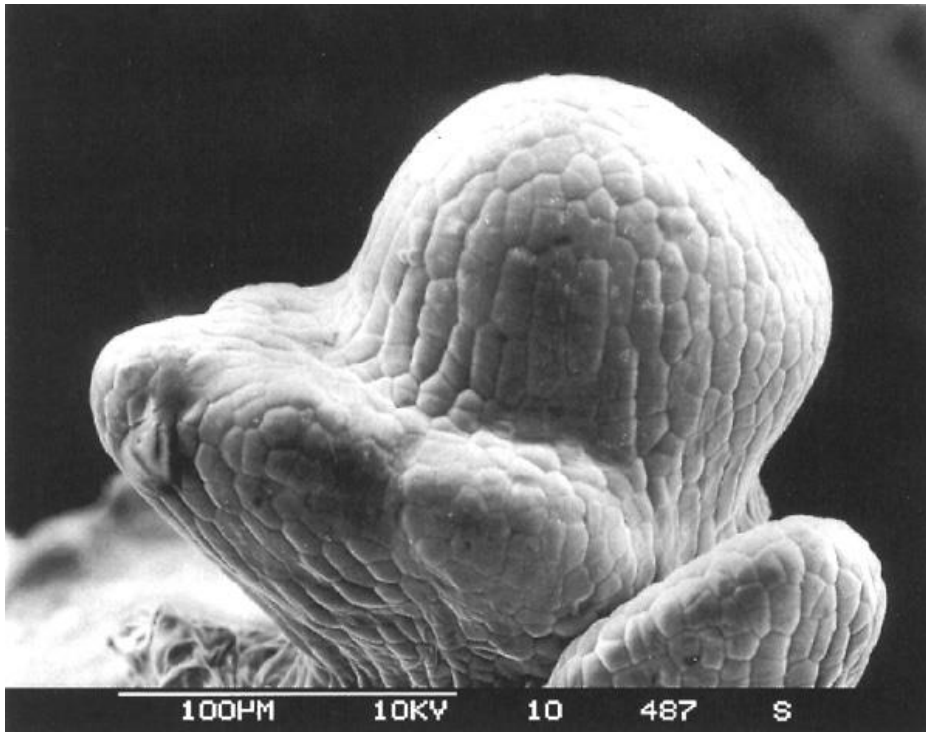
R.Rutishauser

How are nodes & internodes formed during shoot development?

Distichous primordia arrangement (pea *Pisum sativum*):

alternating **wedge-shaped future node and internode** domains differ in rates of cell divisions and growth

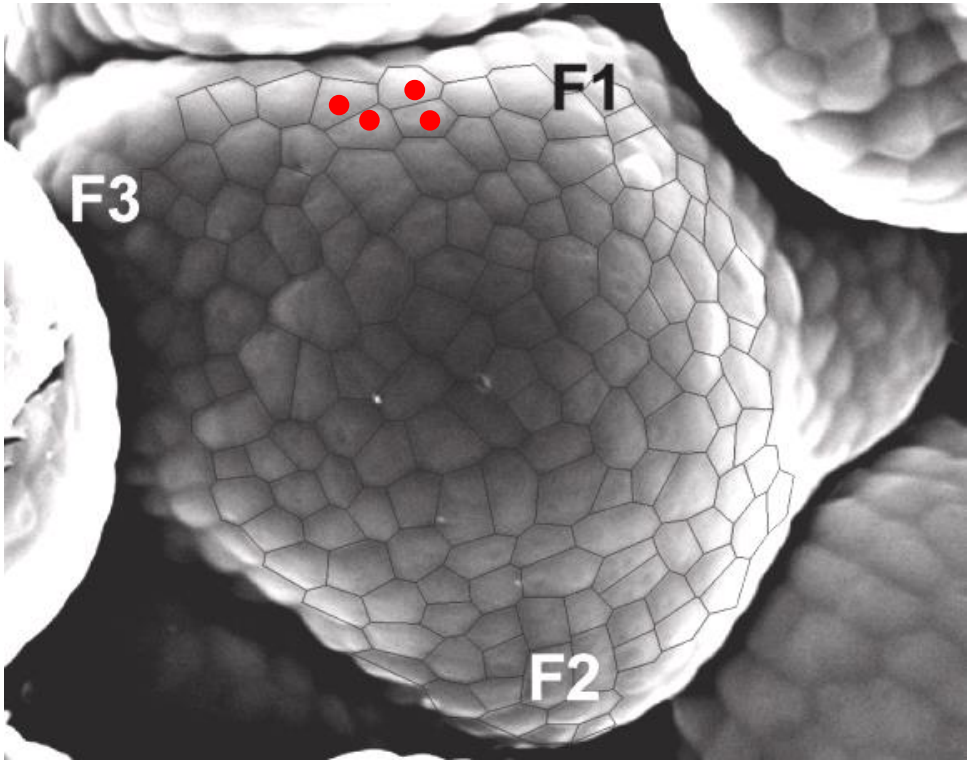




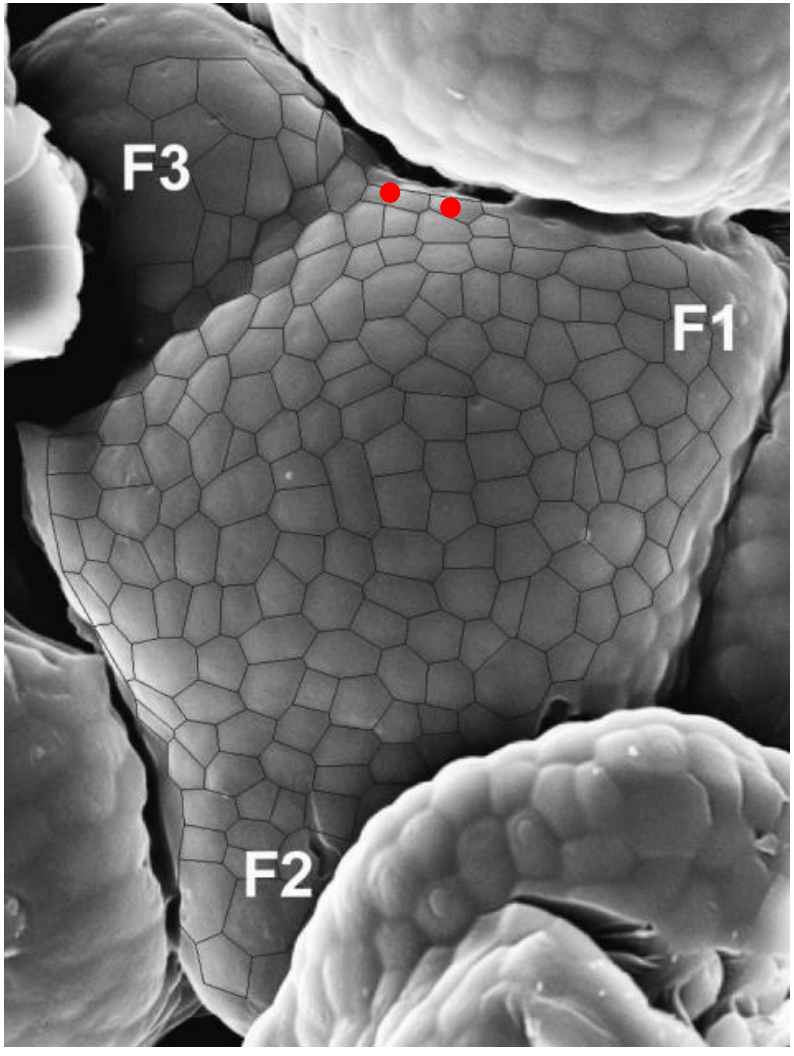
Lyndon „Apical meristems ..”

More complex case of **spiral** primordia arrangement in *Arabidopsis* inflorescence:

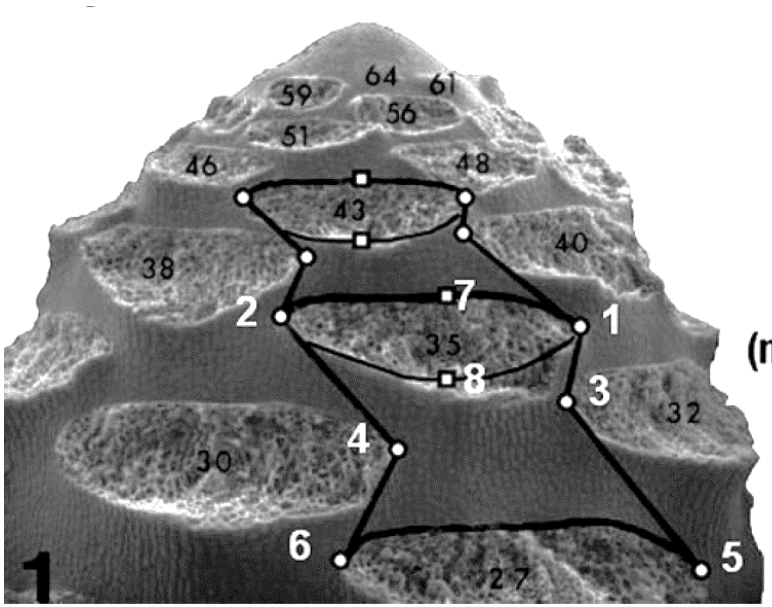
primordium boundaries, abaxial of F1 and adaxial of F3, delimit a part of **two future internodes** in elongated stem (exemplary cells)

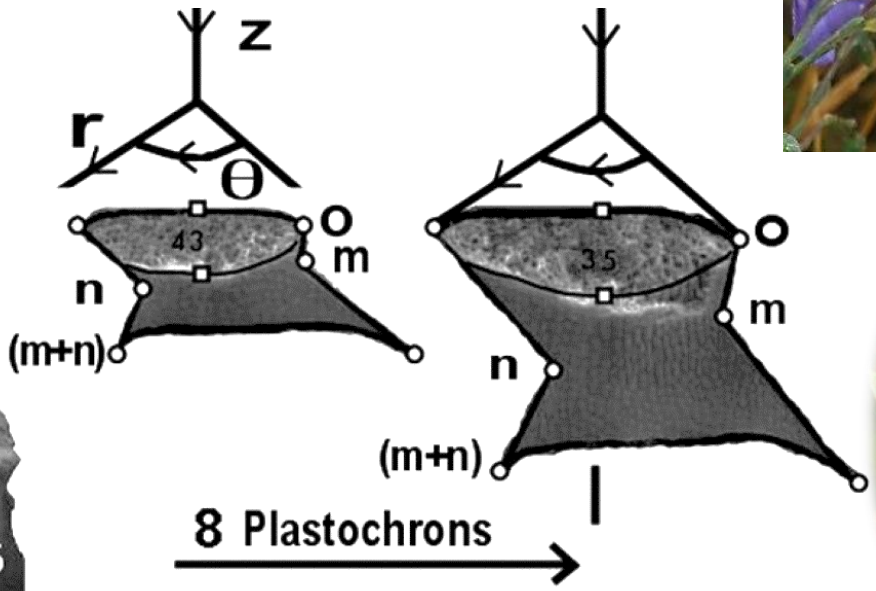


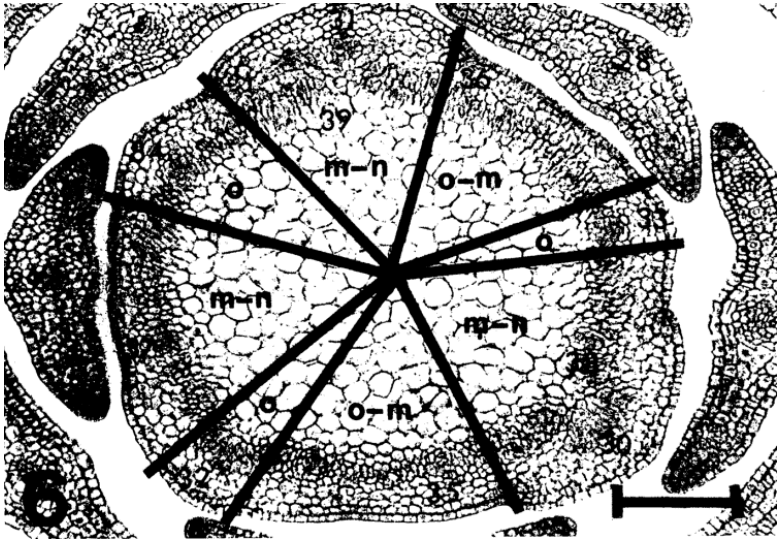
+24h



... and in vegetative shoot of *Linum*







Meicenheimer 1992, 2006

STEM UNITS in *Linum* apex **span 7 future internodes** of elongated stem

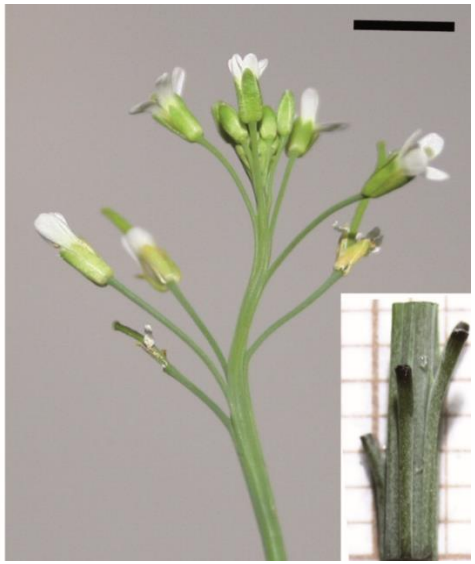
Each unit is delimited by:

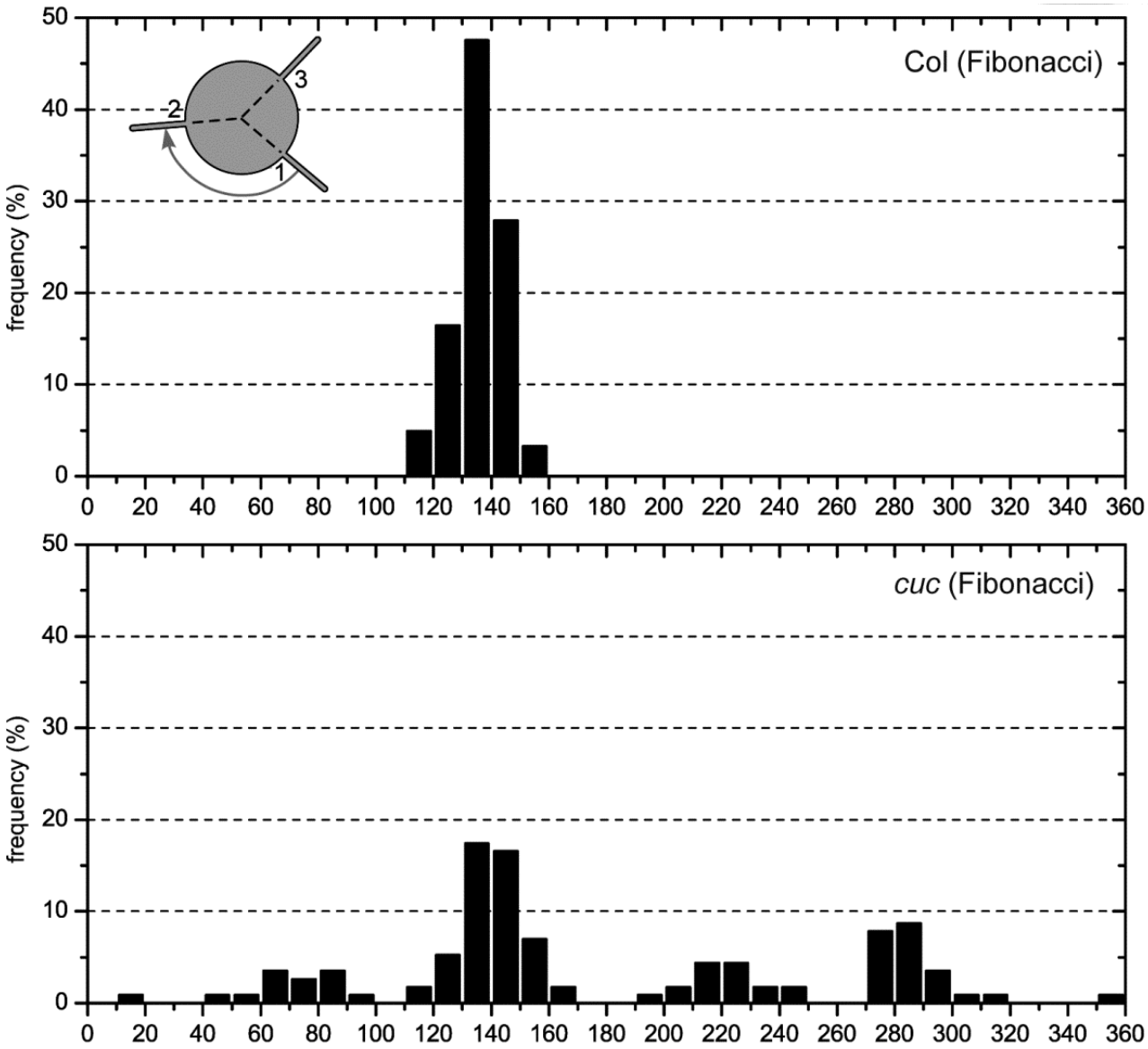
- adaxial primordium boundaries and contact parastichies on apex surface
- stem radii in shoot interior

Stem units are maintained in conifer (e.g. *Picea*) twigs …

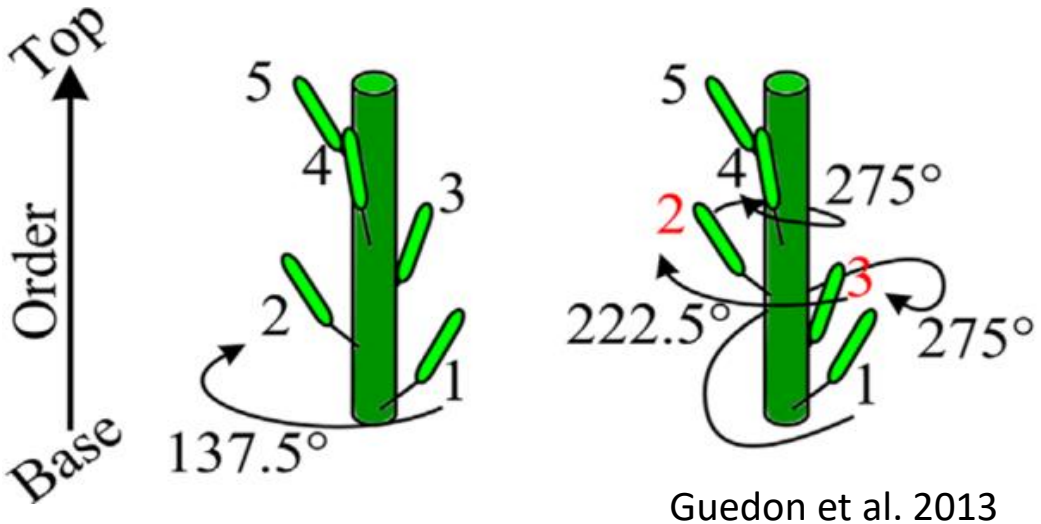
Stem units are maintained in *Arabidopsis cuc2 cuc3,* which affects the elongated stem phyllotaxy

Elongated shoot phyllotaxy – divergence measured along unidirectional helix

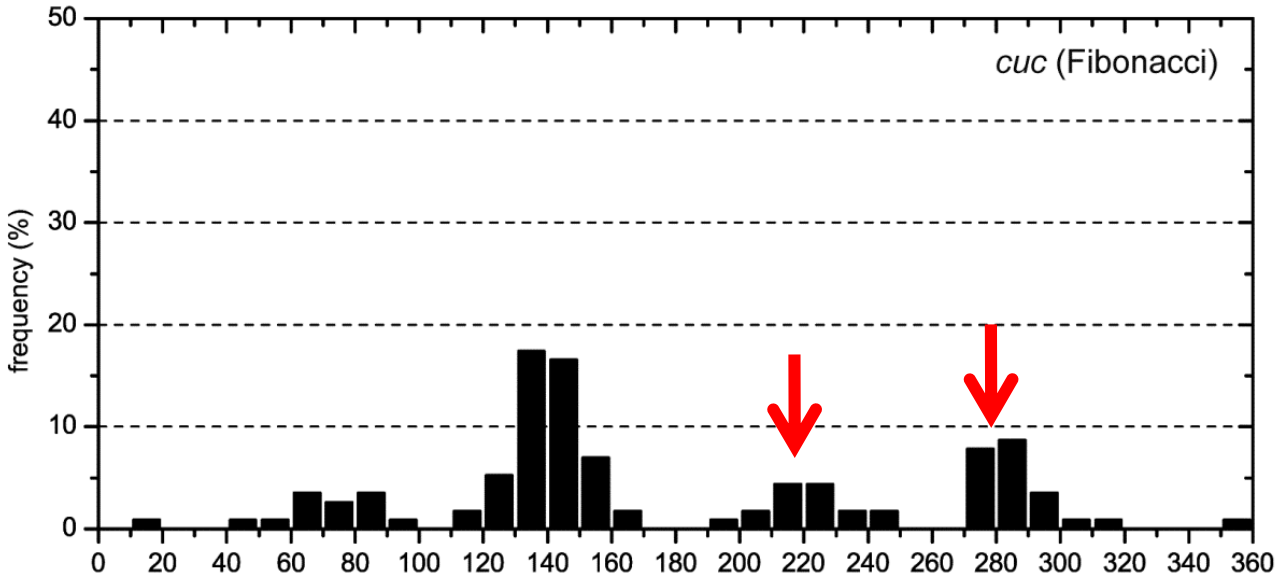




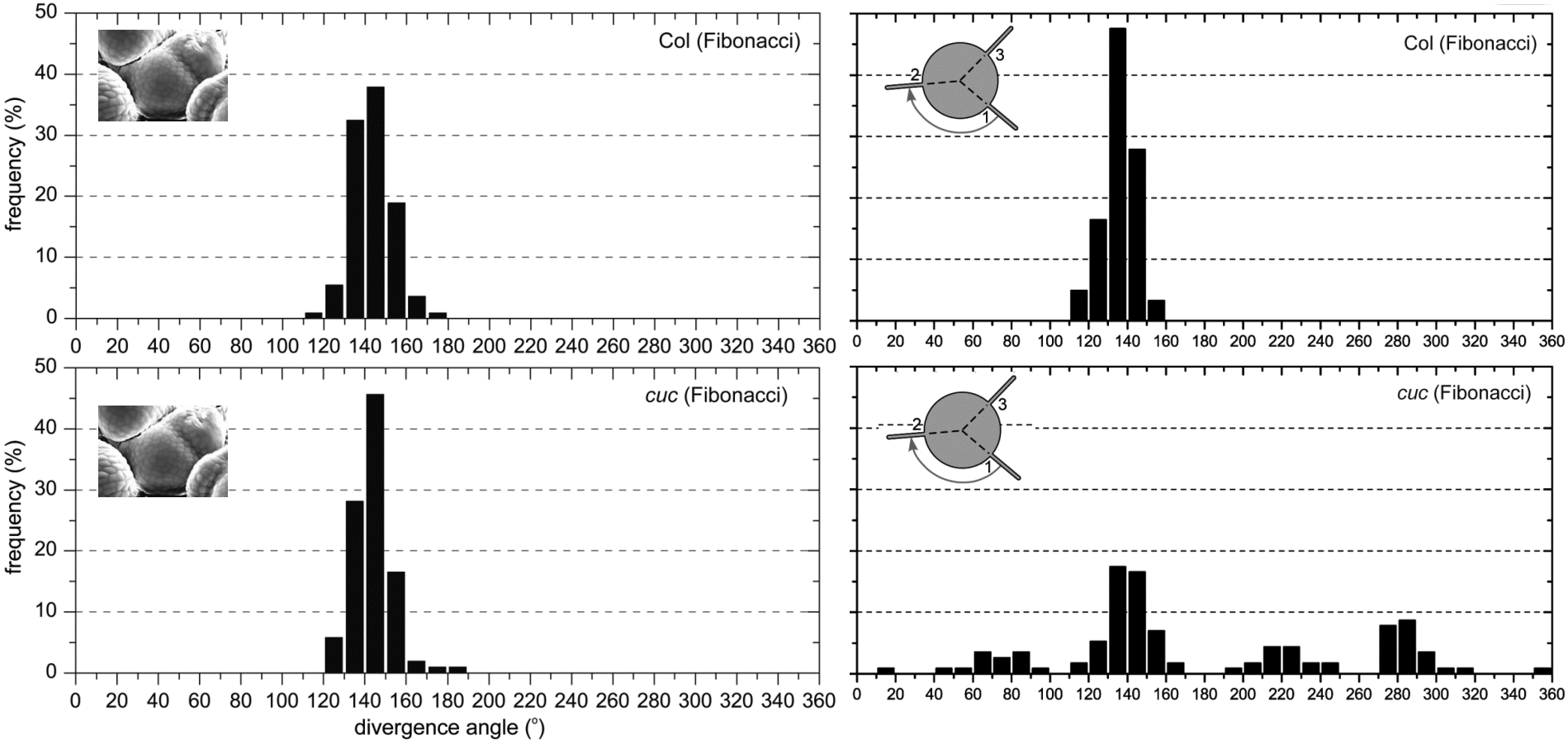
Angles accompanying phyllotactic permutations:



Guedon et al. 2013



Shoot apex *versus* **elongated shoot phyllotaxy** in Col-0 and *cuc2 cuc3*

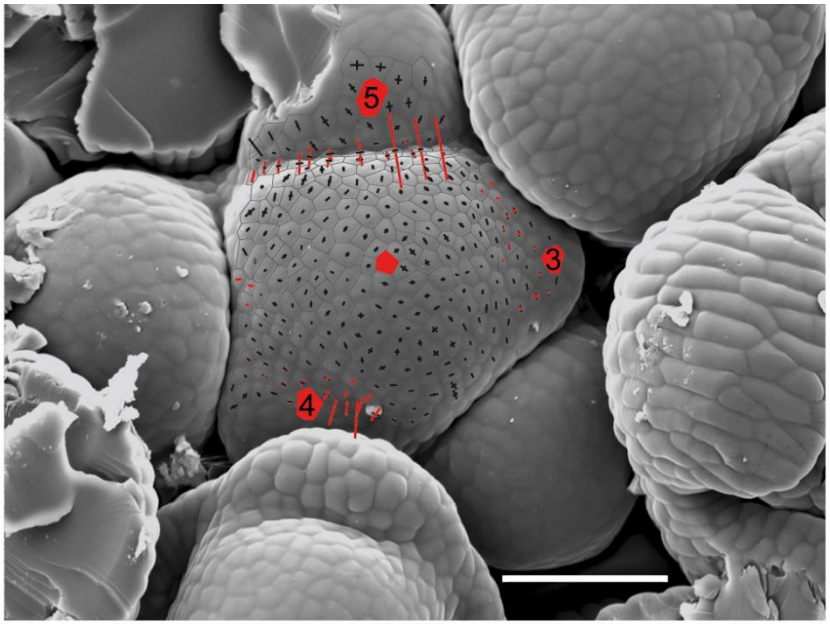


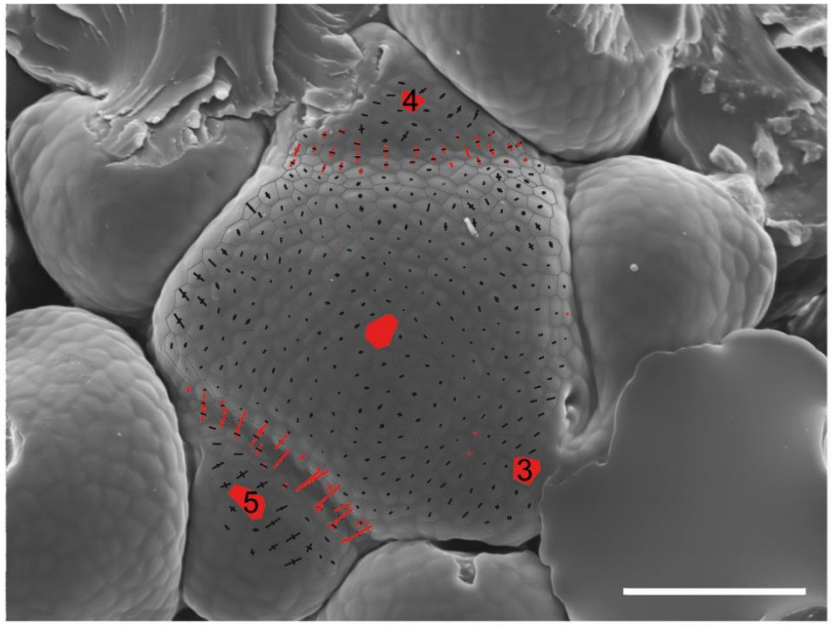
Burian et al. 2015

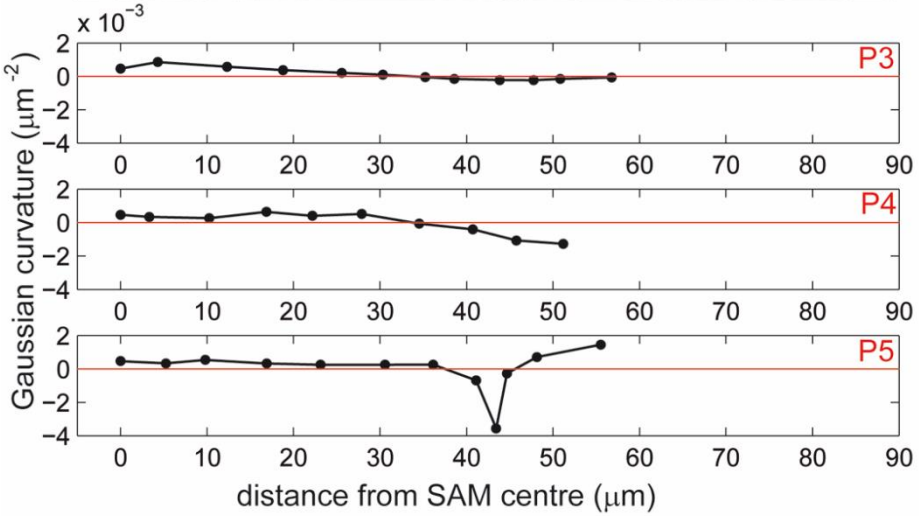
At *cuc2 cuc3* SAM boundary formation in slightly delayed

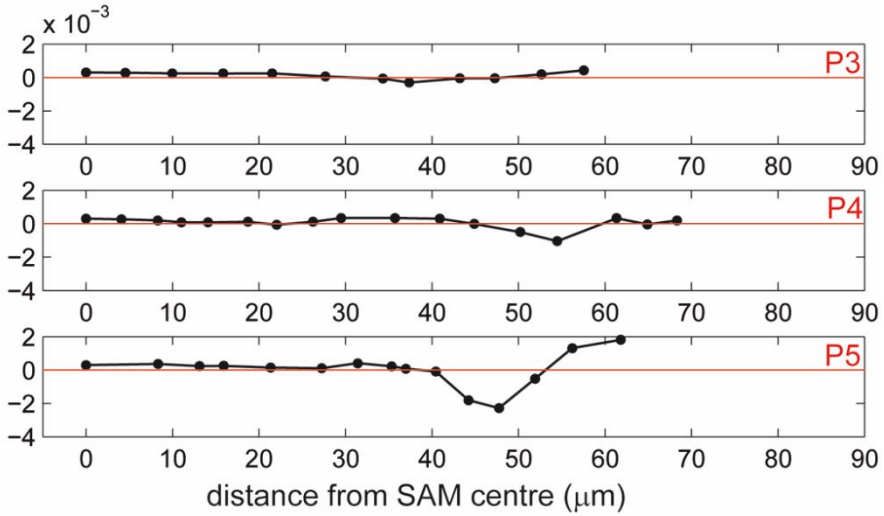
Col-0

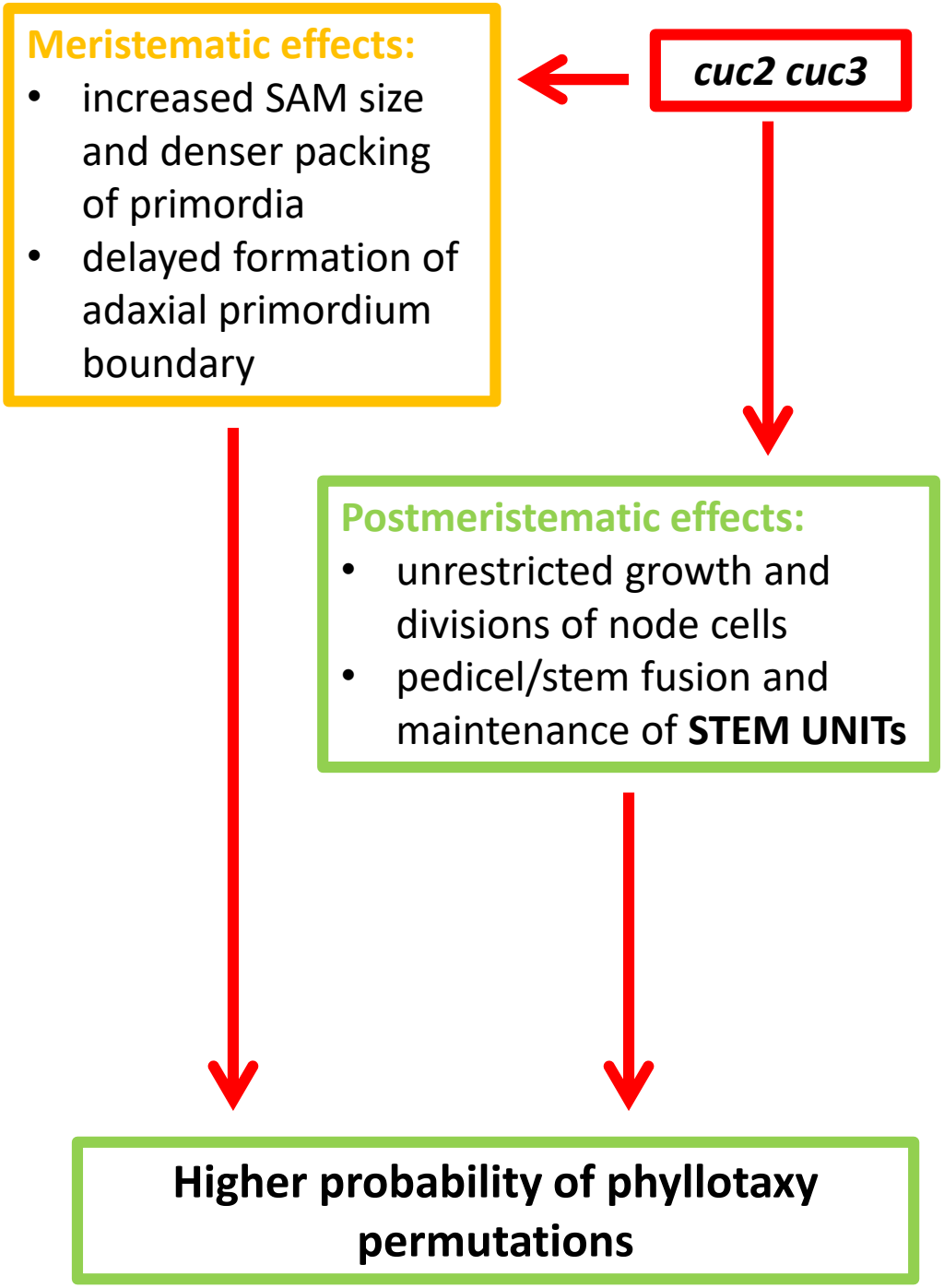
cuc2 cuc3









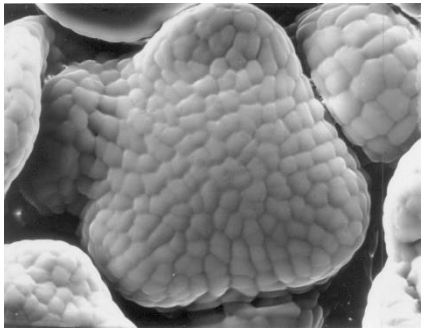


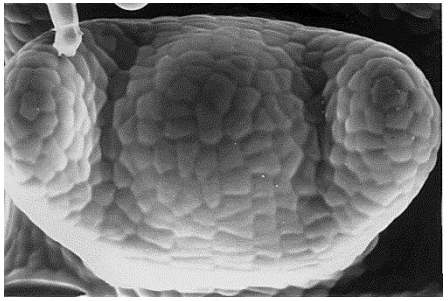
***Arabidopsis* SAM:**

minute aberrations in timing and spacing of primordia initiation → permutations

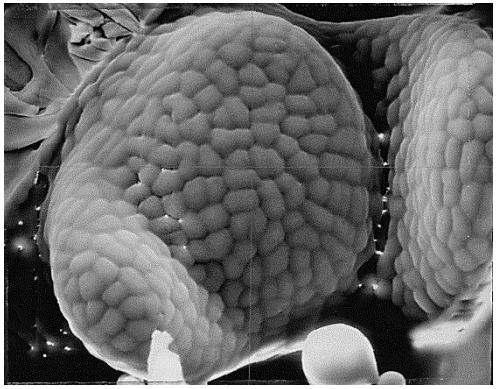
but in others, like *Anagallis*:

← regular nodes
OR
pseudo-nodes →





formed despite „imprecisions” in ← timing OR timing and spacing →



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Thank you for attention